6.2.2 Excavation

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System Design Criteria for the OU 7-10 Glovebox Excavator Method Project

Excavation Design Criteria

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Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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Idaho National Engineering and Environmental Laboratory
Environmental Restoration Program
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
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for the OU 7-10 Glovebox Excavator Method Project

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CONTENTS

ACRONYMS

AMWTP	Advanced Mixed Waste Treatment Project
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
FFA/CO	Federal Facility Agreement and Consent Order
FFS	Facility Floor Structure
INEEL	Idaho National Engineering and Environmental Laboratory
OU	operable unit
RCS	Retrieval Confinement Structure
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SDC	system design description
TFR	technical and functional requirements
TRU	transuranic
WAG	Waste Area Group
WES	Weather Enclosure Structure

System Design Criteria
for the OU 7-10 Glovebox Excavator Method Project

Excavation Design Criteria

1. INTRODUCTION

This Operable Unit (OU) 7-10 system design criteria (SDC) document establishes the excavation design criteria for the OU 7-10 Glovebox Excavator Method Project. It is intended to augment the parent document (i.e., *OU 7-10 Glovebox Excavator Method Technical and Functional Requirements* [INEEL 2002a]) to enable performance of the OU 7-10 Glovebox Excavator Method Project detailed design, engineering, and evaluation activities.

The *Record of Decision: Declaration of Pit 9 at the Radioactive Waste Management Complex Subsurface Disposal Area at the Idaho National Engineering Laboratory, Idaho Falls, Idaho* (DOE-ID 1993) specifies the environmental remediation of transuranic (TRU) waste from OU 7-10 (which comprises Pit 9) of Waste Area Group (WAG) 7. On October 1, 2001, the Idaho National Engineering and Environmental Laboratory (INEEL) published the *WAG 7 Analysis of OU 7-10 Stage II Modifications Report* (INEEL 2001), which identified a feasible approach for retrieving waste from OU 7-10. The project was established to accomplish the objectives presented in that report. The overall objectives for the project are as follows:

- Demonstrate waste zone material retrieval
- Provide information on any contaminants of concern present in the underburden
- Characterize waste zone material for safe and compliant storage
- Package waste zone material in containers acceptable at the Advanced Mixed Waste Treatment Project (AMWTP) Facility.

This project was requested by the U.S. Department of Energy Idaho Operations Office (DOE-ID) in support of the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (FFA/CO) (DOE-ID 1991), OU 7-10 Record of Decision (DOE-ID 1993), *Explanation of Significant Differences for the Pit 9 Interim Action Record of Decision at the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 1998), and Appendix A of the *Remedial Design/Remedial Action Scope of Work and Remedial Design Work Plan: Operable Unit OU 7-10 (Pit 9 Project Interim Action)* (LMITCO 1997).

1.1 Facility Description

The INEEL is a U.S. Department of Energy (DOE) facility, located 52 km (32 mi) west of Idaho Falls, Idaho, and occupies 2,305 km^2 (890 mi^2) of the northeastern portion of the Eastern Idaho Snake River Plain. The Radioactive Waste Management Complex (RWMC) is located in the southwestern portion of the INEEL. The Subsurface Disposal Area (SDA) is a 39-ha (97-acre) area located in the RWMC. Waste Area Group 7 is the designation recognized by Comprehensive Environmental Response,

Compensation and Liability Act (42 USC § 9601 et seq.) and in the FFA/CO for the RWMC, which comprises the SDA buried waste site. WAG 7 has been divided into 13 OUs[a]. Operable Unit 7-10 is located in the northeast corner of the SDA. The OU 7-10 site is an area into which chemicals, radioactive materials, and sludge from DOE weapons plants and other government programs were disposed. While such disposal at the RWMC began in 1952, OU 7-10 was used and filled in the late 1960s. The pit contains characteristic hazardous, listed hazardous, low-level radioactive, and TRU waste.

The project facilities and processes are being designed to safely conduct a waste zone material retrieval demonstration in a selected area of OU 7-10. The project processes consist of excavation and retrieval; sampling, packaging, and interim storage; shutdown; deactivation, decontamination, and decommissioning (D&D&D); and environmental monitoring. Project facilities include a Weather Enclosure Structure (WES), Retrieval Confinement Structure (RCS), excavator, ventilation system, and other supporting equipment. The packaged material will be transported to the AMWTP for preparation for and shipment to the Waste Isolation Pilot Plant.

1.2 Limitations of the System Design Criteria

This SDC document defines the criteria for the excavation design aspects of this project. The SDC flow directly from the project Technical and Functional Requirements (TFR) document (INEEL 2002a), and are intended to include detail not provided in the TFR document, client requirements, and those codes, standards, and regulations that will be used as a basis for the design of the excavation system. Design criteria will be revised as the project proceeds.

This SDC document focuses only on the excavation design criteria. The SDCs for general structures; site, process, packaging, fire protection, facility and infrastructure; and instrumentation and control are addressed in separate documents.

1.3 Ownership of the System Design Criteria

This SDC document is the product of the combined activities of the project team. The project engineer has the ultimate responsibility for the content and approval of this document.

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a. Operable Units 13 and 14 were combined in the 1995 comprehensive remedial investigation and feasibility (Huntley and Burns 1995).

2. OVERVIEW

2.1 Facility Structure, System, Component Functions

The excavator system consists of a Caterpillar Co. 446B backhoe that has been modified to maintain confinement via an interface to the RCS. The backhoe arm will be within the RCS and the operator cab and operator will be outside the RCS in the WES. The system will include the following four end effectors:

- 16-in. wide bucket (the smallest available for the remote coupler)
- 24-in. wide bucket
- 24-in. wide clamshell bucket
- Hydraulic hammer.

The buckets will be used for all excavation from the pit and for moving probes as necessary. The hammer will be used to cut apart intact drums weighing more than 350 lb and to facilitate taking core samples from the underburden.

2.2 Facility Structure, System, and Component Classification

No safety-class structures, systems, or components are associated with this project.

The *Preliminary Documented Safety Analysis for the Operable Unit 7-10 Glovebox Excavator Method* (INEEL 2002b) describes the facility safety basis and identifies its safety- significant design features. It prescribes minimum design criteria and functional requirements for the project to follow. The only components of the excavation system that are classified as safety significant are the RCS excavator interface seals and plates. These components form part of the confinement system, and are thus classified as safety significant. Additional discussion regarding these safety significant components can be located in the *System Design Criteria for the Operable Unit 7-10 Glovebox Excavator Method Project General Structures and Site Design Criteria* (INEEL 2002c). In addition, the excavator stands, excavator stops, and bulkhead fittings are all considered low-safety consequence.

2.3 Operational Overview

This project includes systems to support retrieval and packaging of waste zone material. The site where the facilities will be located has 6-in. diameter probes that were installed to refusal during Stage I of the OU 7-10 Staged Interim Action Project. These probes may be moved and placed in another area in the pit as necessary during waste zone material retrieval to facilitate retrieval and underburden sampling operations. Overburden will be excavated and packaged in soil sacks before disturbing waste zone material.

A manned excavator will retrieve waste zone material. The operator will be located in the WES outside the RCS. The excavator arm, contained within the RCS, will excavate an angular swath. The retrieved material in the excavator bucket will then be placed into a transfer cart. One transfer cart is located at the entrance of each of the three material packaging gloveboxes. The carts transport waste zone material into the gloveboxes, where it will be inspected, sampled, and packaged. Waste packages will then be transported to the AMWTP.

After waste zone material excavation is complete, samples of the underburden will be taken and the pit will be backfilled for closure before deactivation, decontamination, and decommissioning.

The retrieval equipment provides efficient excavation of the overburden and waste zone material as well as sampling of the underburden. The excavator equipment supports three primary operations, as described in the paragraphs that follow.

2.3.1 Overburden Removal

The overburden is excavated inside the RCS confinement. Before soil removal with the excavator, it may be necessary to manually remove some of the soil in the area of the probes that the excavator cannot reach without probe interference. The excavator, working through the confinement wall, excavates the first 3.5-ft depth of overburden in a circular section with a 145-degree arc and 20-ft radius.

Excavated soil is placed in 4 × 4 × 4-ft soil sacks, which are staged in the 35-degree area on the Facility Floor Structure (FFS) that is not excavated. The soil sacks are removed from the confinement and stored outside of the WES for later disposition.

2.3.2 Waste Zone Material Removal

The waste zone material is removed after all of the overburden has been removed. The jaw bucket end effector excavates the waste and interstitial soil and places it on the glovebox waste transfer cart; excavated drums are moved using the bucket in the split mode where it functions as a clamshell tool.

2.3.3 Underburden Sampling

Once the waste zone material has been removed, and operations determines that underburden has been reached, excavation stops and underburden sampling begins.

Before sampling, the jaw bucket is placed on the 35-degree laydown area and remotely detached. The hydraulic hammer is then remotely attached using the automatic pin grabber at the end of the excavator stick. The hammer is fitted with the soil sampler to take a 2-in. diameter sample from the underburden. Hydraulic lines on the hammer are connected to the excavator boom lines using gloveports at the west wall of the RCS. The excavator operator then positions the hammer over the area to be sampled and energizes the hammer to drive the sampler and obtain the sample. The sample is removed from the tube at the gloveports. The process is repeated until the required samples are obtained.

3. DESIGN CRITERIA AND BASES

The excavation system retrieves the overburden and waste zone soil and waste from the pit and places it on a cart for transport into the gloveboxes.

3.1 Operational Design Criteria

The following operational design criteria are specific to the excavator system:

1. The excavation system shall be based on a Caterpillar Co. 446B backhoe.

   Basis: This excavator has all the features and is the size and quality required for this task. In addition, this excavator meets the requirement of utilizing commercially available, off-the-shelf equipment. TFR Section 3.1.3-1.

2. The excavator shall be capable of attaining 180 degrees of horizontal motion, and have the ability to excavate in a 20-ft radius.

   Basis: This is required to ensure that enough material is removed from the pit and to expose the underburden for sampling. TFR Section 3.1.1.1-4.

3. The excavator system shall be capable of removing between 75 and 125 yd^3 of waste zone material.

   Basis: WAG 7 Analysis of OU 7-10 Stage II Modifications, Section 2.1, Recommended Approach, and 4.3.1, Modification Description. This is a baseline project requirement imposed in the TFR Section 3.1.1-4. TFR Section 3.1.1.1-4.

4. The excavator system shall remove overburden from the selected retrieval area before waste zone material retrieval.

   Basis: WAG 7 Analysis of OU 7-10 Stage II Modifications, Section 4.3.1, "Process Description." The angular area shown will be braced with a vertical-side shoring box. The excavation system will remove the overburden contained within the shoring box. Overburden must be removed to gain access to the waste zone material. TFR Section 3.1.2.1-1.

5. The excavator system shall remove waste zone material from the selected plot in OU 7-10 subject to the constraints of the angular swath of the excavator and the angle of repose achieved in the pit excavation.

   Basis: WAG 7 Analysis of OU 7-10 Stage II Modifications, Section 4.3.4, "Risk Estimate," Table 4.3-8. Waste zone material includes waste and interstitial soil. The project site will be selected to avoid the known large object exceptions. Volume and mass limitations are based on equipment that will be used (routine use) for mass handling, and volume capacity, as described in the WAG 7 Analysis of OU 7-10 Stage II Modifications. TFR Sections 3.1.1.1-4 and 3.1.2.1-3.

6. The excavator system shall obtain 2-in. diameter by maximum 5-ft long core samples of the underburden below the retrieval area.

Basis: Samples from the underburden will be 2-in. nominal cores. The quantity of samples will be identified in the project Field Sampling Plan (Salomon et al. 2002). These samples will be used to determine if contaminants have migrated to the underburden. TFR Sections 3.1.2.3-3 and 3.1.2.3-5.

7. The excavator system shall be capable of retrieving intact waste containers estimated to weigh a maximum of 1,000 lb.

   Basis: This includes intact waste containers that are empty or contain TRU, low-level, mixed, and hazardous waste material. The weight is based on lifting a 55-gal drum of solidified materials. TFR Section 3.3.1-3.

8. The excavator system shall be capable of retrieving waste zone materials consisting of loose debris and sludge.

   Basis: Waste from the project excavation zone must be retrieved. Some drums containing the waste may be deteriorated and therefore, it will be necessary to retrieve the waste that was from those drums. TFR Section 3.1.2.2-2.

9. The excavator system shall have at least one end effector system that can pick up an intact 55-gal drum.

   Basis: Waste from the project excavation zone must be retrieved. Some drums may be intact, and therefore, must be retrieved in an intact state. TFR Section 3.3.1-3.

10. The RCS excavator seal shall be designed to accommodate anticipated excavator movements.

    Basis: Flexibility is necessary to allow movement of the excavator arm without damaging the RCS and compromising confinement. TFR Section 3.1.1.1-2.

11. The excavator refueling shall be accomplished manually.

    Basis: To reduce complexity of refueling and to remove a source of fire. TFR Section 3.3.7-1.

12. The excavator materials shall be compatible with the radioactive and hazardous waste expected to be encountered in the excavation.

    Basis: To ensure reliability of the excavator. Reactions with hazardous or radioactive waste material may cause corrosion and general deterioration. Information regarding compatibility with the radioactive and hazardous waste can be located in EDF-2041 and EDF-ER-211.

13. The RCS excavator seal material(s) are Safety Significant and shall be compatible with the radioactive and hazardous waste expected to be encountered in the excavation.

    Basis: To ensure reliability of the excavator seal boot material. Reactions with hazardous and radioactive waste materials may cause deterioration of the seal boot, potentially causing a breach of confinement. Information regarding compatibility with the radioactive and hazardous waste can be located in EDF-2041 and EDF-ER-211.

14. The excavator shall be equipped to support remote coupling with the end-effectors.

Basis: Reduce the entries and time personnel are in the confinement area. Supports ALARA goals. Performance without requiring personnel access to the excavation pit or entry into the confinement during systems operation is preferred based on reducing the risk of chemical or radioactive exposure and to reduce the potential for physical injury to workers. TFR Sections 3.2.2-1, 3.2.2-2, 3.2.2-3, and 3.2.6-1.

15. The excavator shall have accessory tools capable of driving 2.75-in. diameter metal core sample tubes into the underburden.

    Basis: To determine the extent of contaminant migration into the underburden. TFR Sections 3.1.2.3-3 and 3.1.2.3-5.

16. The reach of the excavator bucket shall be between 24 and 26 ft from the excavator pivot point, in a horizontal direction, at ground level.

    Basis: This is necessary to load the glovebox cart with waste. TFR Sections 3.1.1.1-4, 3.1.2.1-1, and 3.1.2.1-3.

17. The excavator cab area shall contain at least one video monitor, which can display images from any of the video cameras in the RCS.

    Basis: Provide visual information to the excavator operator for bucket positions that he cannot directly observe. This will also allow zooming for a magnified view of the waste zone material. Performance without requiring personnel access to the excavation pit or entry into the confinement during system operation is preferred based on reducing the risk of chemical or radioactive exposure and to reduce the potential for physical injury to workers. TFR Section 3.2.2-1, 3.2.2-2, 3.2.2-3, and 3.2.6-1.

18. The excavator exhaust shall be ducted outside of the WES.

    Basis: The exhaust cannot be vented inside the WES due to carbon monoxide concerns. TFR Section 3.2.4-1.

19. The excavator shall interface with the RCS and the FFS.

    Basis: The RCS forms a barrier between the operator and the confinement. TFR Section 3.1.1.1-2.

20. The excavator shall be capable of having all of its lubrication fittings in the WES lubricated without manned entry into the RCS.

    Basis: Minimizes entries into the confinement for maintenance. Performance without requiring personnel access to the excavation pit or entry into the confinement during system operation is preferred based on reducing the risk of chemical and radioactive exposure and to reduce the potential for physical injury to workers. TFR Sections 3.2.2-1, 3.2.2-2, 3.2.2-3, 3.2.6-1, and 3.4.4-1.

21. The excavator shall be able to size an intact drum in the pit in a manner that does not contaminate the surrounding waste zone or the underburden.

Basis: Drums that exceed the 350-lb weight limit of the transfer cart and the packaging glovebox system will require sizing at the digface. TFR Sections 3.3.1-4 and 3.3.1-5.

22. The excavator shall be capable of determining the vertical distance from grade to the tip of the bucket for ensuring that waste zone material is not disturbed during overburden removal. In addition, this system can be used to record the depth and reach of each bucket of retrieved waste zone material.

Basis: Only the top 3.5 ft of overburden will be removed. Monitoring must be provided to inform the operator of when the 3.5-ft limit has been achieved. TFR Sections 3.1.2.1-1 and 3.1.2.1-2.

23. The excavator shall be capable of determining the weight of an intact drum weighing 330 lb within ± 20 lb as it is held by the jaw bucket. The excavator will be calibrated using a known weight.

Basis: The excavator must provide a crude weight of the excavated waste zone material to ensure the 350-lb limit imposed on the transfer cart and packaging glovebox system is not exceeded. TFR Sections 3.3.1-4 and 3.3.1-5.

24. The excavator swing, boom raise and lower, stick, and curl cycle time shall be reduce by one-half.

Basis: The speed of the excavator swing, boom raise and lower, stick, and curl will be reduced to aid in collision control and operator dexterity.

25. The excavator shall be equipped with air conditioning.

Basis: The excavator must be air conditioned to support operator health and safety, as imposed by the project Health and Safety professional.

26. The excavator power steering and brakes shall be disabled.

Basis: The excavator is stationary; therefore, by disabling the power steering and brake hydraulics, contamination of the hydraulic system is minimized.

3.2 Accident Design Criteria

The following accident design criteria are specific to the excavator system:

1. During the unlikely event of a fire in the pit during excavation operations, the excavator shall be capable of placing dry fire suppressant material on the fire to smother it.

Basis: To aid in fire suppression. TFR Sections 3.3.7-1 and 3.3.7-3.

2. Containers or bins shall be provided in the RCS on the FFS for containing dry fire suppressant and dry liquid absorbent for deployment by the excavator during waste zone material operations.

Basis: To aid in fire suppression and stabilization of free liquids. TFR Sections 3.3.7-1 and 3.3.7-3.

3. The volume of dry fire suppressant and dry liquid absorbent in each bin shall be a minimum of 2 ft^3.

Basis: TFR Sections 3.3.7-1 and 3.3.7-3.

4. The dry fire suppressant shall be magnesium oxide sand.

   Basis: TFR Sections 3.3.7-1 and 3.3.7-3.

5. The dry liquid absorbent shall be asbestos-free, dry, exfoliated vermiculite particulate.

   Basis: TFR Section 3.1.2.2-4.

6. The suppressant and absorbent shall be able to be obtained by the excavator buckets without entry of personnel into the RCS.

   Basis: Personnel will not be allowed in the RCS for deployment of suppressants and absorbents. TFR Sections 3.1.2.2-4, 3.3.7-1, and 3.3.7-3.

7. The containers or bins shall be designed so that either the 24-in jaw bucket or the 16-in bucket can obtain and deploy the suppressant and absorbent materials.

   Basis: The suppressants and absorbents must be capable of being deployed by the excavator bucket currently in use at the time of need. TFR Sections 3.1.2.2-4, 3.3.7-1, and 3.3.7-3.

8. The containers or bins shall be substantial enough that they will not be damaged by normal operation of the excavator bucket.

   Basis: TFR Sections 3.1.2.2-4, 3.3.7-1, and 3.3.7-3.

9. The excavator shall be able to place the suppressant and absorbent at any point in the excavation area.

   Basis: The excavator is the sole means of deployment for the suppressant and absorbent, which may be needed at any point within the excavation area. TFR Sections 3.1.2.2-4, 3.3.7-1, and 3.3.7-3.

10. The excavator shall have an onboard fire suppression system that will deliver fire retardant to a fuel fire inside the engine compartment.

    Basis: Minimize the potential for fires. TFR Sections 3.3.7-1, 3.3.7-3, and 3.3.7-4.

11. The excavator shall use a Factory Mutual approved Type II hydraulic fluid.

    Basis: Minimize the potential for fires. TFR Section 3.3.7-1.

12. The excavator shall be fastened to the FFS so that it will not move and damage other equipment during an earthquake. Refer to earthquake criteria in the *System Design Criteria for the Operable Unit 7-10 Glovebox Excavator Method Project General Structures and Site Design Criteria* (INEEL 2002c).

    Basis: In accordance with DOE Order420.1, "Facility Safety," and Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," systems, structures, and components shall be designed, constructed, and operated to withstand the effects of natural phenomena as necessary to ensure the

confinement of hazardous material, the operation of essential facilities, the protection of government property, and the protection of life safety systems. TFR Section 3.2.5-1.

13. The excavator shall not breach the RCS excavator seal during a design basis seismic event.

    Basis: In accordance with DOE Order420.1, "Facility Safety," and Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," systems, structures, and components shall be designed, constructed, and operated to withstand the effects of natural phenomena as necessary to ensure the confinement of hazardous material, the operation of essential facilities, the protection of government property, and the protection of life safety systems. TFR Section 3.2.5-1.

14. The restraint supports between the excavator and the FFS shall be rated as PC-2 for earthquake loads only. Refer to earthquake criteria in the *System Design Criteria for the Operable Unit 7-10 Glovebox Excavator Method Project General Structures and Site Design Criteria* (INEEL 2002c).

    Basis: Because failure of the restraints can potentially pose a threat to the safety significant RCS. TFR Section 3.2.5-1.

3.3 Safety Significant Items

The RCS excavator seal and the internal plate seal inside the excavator frame are safety-significant items.

3.4 Applicable Regulatory and Contractual Requirements

The following regulatory and contractual requirements are specific to the excavator system:

DOE-STD-1090-2001, "DOE Standard Hoisting and Rigging" (April 2001).

3.5 Applicable Industry Codes and Standards

The following industry codes and standards are specific to the excavator system:

- Society of Automotive Engineers (SAE) J 31, *Hydraulic Backhoe Lift Capacity* (March 1986)
- SAE J 43, *Axle Application Load Rating for Industrial Wheel Loaders and Backhoe Loaders* (February 1998)
- SAE J 1040, *Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry and Mining Machines* (May 1994)
- SAE J 1166, *Sound Measurement - Off-Road Self-Propelled Work Machines Operator-Work Cycle* (October 1998)
- SAE J 1179, *Hydraulic Excavator and Backhoe Digging Forces* (February 1990)
- SAE JI7451, *Earthmoving Machinery - Volumetric Rating for Backhoe Buckets* (January 1999).

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